A CONTRIBUTION TO THE STUDY OF ILLUSIONS,[1]

WITH SPECIAL REFERENCE TO

(*a*) THE EFFECT OF SIZE UPON ESTIMATIONS OF WEIGHT,
(*b*) THE EFFECT OF CONTOUR UPON ESTIMATIONS OF AREA.

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This study grew out of a general study instituted by Professor Jastrow, in 1892, for the purpose of studying the possibility of suggestibility in normal individuals. It was first directed toward a study of the creation of actual illusions of certain types. For example, an illuminated surface was made to appear to grow brighter, a space made to appear to grow larger, a sound to grow louder, or a heated tube to grow hotter, without actually becoming so.

In this connection it was important to determine how great was the actual illusion and how suggestible each of the senses might be. Some results from this line of research may be found embodied in a thesis on "A Study of Sensibility with Special Reference to Suggestion," prepared by Messrs. G. M. McGregor and B. R. Shurly, and deposited in the library of the University of Wisconsin.

As a further contribution, it was deemed important to make a study of certain relations of sense perceptions to each other, which would lead to a quantitative determination of the influence one sense may have in acting as a suggestive factor over another.

This study grew out of the former study, and was outlined when the announcement of Dr. Gilbert's article was first made and when a description of Seashore's "Suggestion Blocks" was given in Willyoung's catalogue of supplies. Hence, to make the results conformable, the same size of blocks was determined upon for this study. The methods of experimentation, however, were unknown at the time and

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[1] A minor thesis submitted as a partial requirement for the degree of Master of Science in Pedagogy, University of Wisconsin, 1896.

consequently the methods are only partially coincident. Since the experiments were begun (just before commencing the tabulation of results), a very thorough and exhaustive study was published by Dr. Seashore under the title "Measurements of Illusions and Hallucinations of Normal Life" (*Studies from Yale Psychological Laboratory*, Vol. III, 1895). Another treatment of the same subject from a little different standpoint in the previously mentioned article by Dr. Gilbert preceded Dr. Seashore's article. (See *Yale Studies*, Vol. II, 1894, article, "Researches on the Mental and Physical Development of School Children.") The latter's subjects were children, while Dr. Seashore's and those herein considered were adults, mainly from college classes. Hence, the following contribution will be for the first part mainly corroborative of what has already received fairly adequate treatment.[1] A few variations in method and in results will be noted. The second part deals with a problem heretofore unworked.

PART I.

Apparatus.

Two sets of cylindrical discs, 31 mm. long, were made of wood which was painted black so as to represent a uniform surface. The first set (*U*) consisted of 17 discs 31 mm. long, and having a uniform diameter of 60 mm., but of weights varying by 5 g. each in a constant arithmetical progression. The lightest was 20 g. and the heaviest 85 g. in weight. The second set (*V*) consisted of 13 discs so made as to have a constant weight of 55 g. each, but varying in diameter by a regular increment of 0.1. The set contained the following sizes:

29.28 mm.	47.15 mm.	69.04 mm.
32.21 "	51.87 "	75.94 "
35.43 "	57.06 "	83.54 "
38.97 "	62.76 "	91.89 "
42.87 "		

[1] In this connection mention should be made of Dr. F. B. Dresslar's contribution in the "Studies in the Psychology of Touch," this JOURNAL, VI, June, 1894. One part of the study deals with the illusions of weight produced by size. His weights were of constant diameter, but of varying heights.

These are essentially the same as Seashore's "B."

Two racks, resembling the keyboard of a piano, were made containing a set of 18 levers or keys about 200 mm. in length, placed side by side and balanced in the middle upon a brass rod, which served as a fulcrum for all. Glass bearings were provided to reduce the friction to the minimum. On one end of each lever a mortise was made to hold the respective discs. A point was found on the opposite end of each lever, where a pressure just equal to the weight on the other would just balance the weight. On this spot a rubber button was fastened to indicate the point. Each of the racks was provided with a movable screen so that in the first experiment in each series the observers had no knowledge of the size, shape, or other qualities of the discs.

Exp. I, Series I. Set "U."

Lever pressure method. Discs screened from view.

With the discs (*U*) screened from view the observer was asked to seat himself by the side of the rack, and by pressing upon the buttons on the keys, to select a weight just equal to the one on a certain key which contained the standards. The subjects were informed that the discs formed a weight series, and were also told the direction of the series.

For standards I used five discs, three of which were 60 mm. in diameter and weighed 35 g., 50 g. and 65 g. respectively; the other two weighed 55 g. each, but one ("l") was 90 mm., and the other ("s") 30 mm. in diameter. The only instructions given to the observers were that by first testing the standard, they should select, with the same hand and same finger, a weight just equal to the standard. Each one was at liberty to refer alternately to the standard as many times as he chose. However, if too many trials were made the subject was cautioned against fatigue. Usually the judgments were the best if only two or three repetitions were made with the standard and the one thought to be about right. If more trials were made, the subject frequently abandoned the first one and selected one not so nearly correct. In such cases a second trial was given later on.

The standards were presented in an irregular order, and were removed each time, so that the observers did not know throughout the whole series that they had tested the same one more than once. Each of the twenty-five observers was given two trials with each standard.

The first experiment was made with the discs screened from view, so as to be assured that no illusion could possibly arise

in that way, and to show that the selections were not mere chance guesses. Incidentally, it was a test of the accuracy of selection of equal weights by the lever pressure method. The results of the averages of 50 trials with each standard are as follows;

TABLE I.

Uniform series. Lever pressure. Screen.

Standards.		Average weight of disc selected.	Average variation.	Diameter of Series.
Diameter.	Weight.			
60 mm.	35 g.	29.02 g.	6.95 g.	60 mm.
60 "	50 "	38.05 "	12.6 "	60 "
60 "	65 "	52.17 "	13.48 "	60 "
"l" 90 "	55 "	47.39 "	10.5 "	60 "
"s" 30 "	55 "	47.60 "	9.8 "	60 "

("l" indicates the disc 90 mm. in diameter and "s" the one 30 mm. in diameter, throughout the discussion.)

From the table we see that all the average selections are brought within a range of 10% of each other. The table shows in the first three lines that in comparing by the muscle pressure method, when selecting from the series in exactly the same manner as the standard is tested, there is a decided tendency to choose too small a weight. This is true of all three weights and the decisions are uniformly in one direction. Of the 150 judgments there were only seven in the opposite direction, *i. e.*, only seven were selections greater than the standards. These seven answers were confined to five persons; hence, we have over 80% of the subjects and 95% of the answers in partial concord concerning this tendency.

The three discs were underestimated by about 6 g., 12 g., and 13 g. respectively. This result does not at all agree with Dr. Seashore's. He finds when the weights were concealed from view there was no tendency to underestimation or exaggeration, and further that the difference between the standard and the ones selected never exceeds 2 grams on the average.[1]

We find further that the large disc "l" and the small one

[1] See p. 10, Table IV, Seashore's article. His method, however, was different.

"s" are underestimated, although not seen, and in about the same proportion as the other three. It is noticeable that "l" and "s" have selections made for them which are equal to each other, and also that the average variation for these two are practically the same. This shows that chance has not determined the answers, and that the same tendencies are operative, whatever the size or shape of the objects, when not seen. The cause of the tendency to underestimation is at present unexplainable.

Exp. 2, Series I.

Lever pressure—Set "U." Discs in sight.

With the screen removed from the rack the observer was requested to select in the same manner as before discs that were equal in weight to each of the standards. Thus, in this experiment, the muscle pressure method was used, but was aided by sight. Each of the five standards was given twice to the 25 observers, making 50 experiments with each standard. The object of this test was to determine quantitatively how great an influence, if any, sight has upon judgments relating to weight. In other words, to determine whether sight acts as a suggestive factor in producing illusions of weight. In this experiment the following tabulated results were obtained:

Table II.

Uniform Series—Lever pressure—In sight.

Standards.		Average weight of disc selected.	Average variation.	Diameter of series.
Diameter.	Weight.			
60 mm.	35 g.	28.3 g.	8.0 g.	60 mm.
60 "	50 "	38.5 "	12.4 "	60 "
60 "	65 "	50.7 "	14.3 "	60 "
90 "	55 "	43.1 "	12.4 "	60 "
30 "	55 "	51.8 "	7.3 "	60 "

It will be noted that for the first three used as standards the results are almost identical with those of the first three in Table I. This agreement is as we should expect, since these three standards are of the same size, shape, color, and in every visible way exactly like those selected from. We find

again the same strong tendency to underestimation that was observable in Table I. There is a deviation, however, in case of "l" and "s." For "l" the selection in the previous table was 4.2 g. *larger*, and for "s" the selection was 4.2 g. *smaller* than in the second table. These results show that as soon as sight of the objects comes in to assist in selecting equal weights by the lever pressure method, the tendency to underestimation is reduced, especially in case standards, of unusual density (great or small) are used. However, for the first three there is no appreciable deviation either way.

With the 35 gram standard, four made overestimations; with the 50 g. standard, two made overestimations; with the 65 g. standard there were none; with "l," two; and with "s," eleven who made overestimations. This shows that size acts somewhat as a factor in determining weight, and that illusions tend to be produced by unusually great or small density. The amount of suggestion in grams varies inversely as the increased or diminished diameter of the standard discs. That is, "l" is 30 mm. *greater* in diameter than the series, and the *additional* 30 mm. diameter produces a *decrement* of 4.2 g. in weight; while "s," which is 30 mm. *smaller* than the standards, produces an *increment* of 4.2 g. in weight. From this experiment we conclude from all five lines that: 1. Objects when compared by the lever pressure method are underestimated, even with the additional aid of sight. 2. A variation in density of the objects tends to increase or diminish this tendency. 3. Objects of similarly appearing material, but of different density, appear to differ in weight when compared. 4. The larger induce a decrement of estimated weight; the smaller induce an increment of estimated weight. 5. The intensity of this illusion varies in a direct sense as the amount of difference in diameter between the discs compared.[1] 6. This verifies Weber's law that proportional increments are perceived as equal increments. (Provided we mean diameters.) In the above experiments the diameters were to each other as 3 : 6 : 9, and the increments of weight were perceived as equal.

EXP. 3, SERIES I.

Set "U." Discs in sight. Lifted between thumb and finger.

The next step was to compare the weights by active lifting or "hefting." The most accurate sense of weight is obtained in this way, because we have the additional aid of the tactile

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[1] See Seashore's article, p. 5. He says "directly as the diff. of size." He probably means *diam.*

sense. Of greater importance, also, are the joint sensations which come into play and give added data for judgment. Through long practice in this manner of estimating weight we have become able to make finer discriminations of weight than when any of these factors are omitted.

In this experiment a piece of wood the length of the rack and gouged out, served as a trough, in which the blocks were placed so that the standard discs might be moved into position whereby the same angle of hand and arm could be maintained. The observer was required to grasp the two ends of the discs between the thumb and either fore-finger or middle finger. Therefore, in all cases, the same span, grip and tactile sensations were preserved. Had the observer been allowed to grasp the discs around the circumference, an additional aid in determining volume would have been gained. But the aim was to have the perception of size depend entirely upon sight, as in experiment 2. The results obtained are given in the subjoined table.

TABLE III.

Set "U"—In sight—Active lifting.

Standards.		Average weight of disc selected.	Average variation.	Diameter of series "U."
Diameter.	Weight.			
60 mm.	35 g.	35.5 g.	2.1 g.	60 mm.
60 "	50 "	49.1 "	4.5 "	60 "
60 "	65 "	62.8 "	3.1 "	60 "
90 "	55 "	40.3 "	(—)14.7 "	60 "
30 "	55 "	69.5 "	(+)14.5 "	60 "

In this set of experiments the results of the comparison of the first three standards show no illusion, as they ought not, the size being the same as the discs compared. The only difference between these results and those corresponding in Tables I and II are that in Table III the average weights of the discs selected are much nearer to the standards. This is due to the additional factor mentioned above which is promotive of accuracy. In the first case we find that the average of the estimates is a trifle greater than the standard. The second and third are very much nearer the standards than before, but still underestimated. The average errors are in all three

cases very small, which shows the constant direction of the answers. The illusion produced by the discrepancy between size and expected weight comes out very strongly in case of "l" and "s." Between "l" and the one selected there is a difference of —14.2 g., while between the smaller one, "s," and the one selected there is a difference of +14.5 g. The average errors, of course, coincide with the actual differences, since all *underestimated* in selecting one equal to "l" and *overestimated* in selecting one to equal "s." The deviations from "l" and "s" are numerically equal, but opposite in sign. As in experiment 2, the standards vary from the normal, or from the series, by 30 mm. each in diameter and in opposite directions from the series. We may conclude from this that the same law as was stated in discussing experiment 2 holds true, viz.: that the intensity of the illusion varies in a direct sense as the amount of difference in diameter between the discs compared. In fact, all the laws governing the operations in experiment 2 hold true in this one. The only differences are that by the last method actual weights are more accurately perceived when size is not a modifying factor; and when an illusion is produced by differences in density, the illusion is much stronger by lifting than by the lever pressure method.

Series II.

In the second series of experiments with the same five standards, three sets of experiments were performed. But in this series the set "V" (variable in size) was used to select from. So that in this series we had three standards of equal diameter and two of varying diameter, also a varying set, from which to select. This increase of variable factors rendered the problem a more complex one than the preceding. Bearing in mind that all were 55 g. in weight, and varying in diameter by a regular increment of 0.1, we pass to—

Exp. 1, Series II.

Set "V"—Lever pressure—Screen.

With the discs screened from view of the observers, they were asked to select a disc equal in weight to the standards presented. This time they were uninformed concerning any of the properties of the series. In the same manner by pressure upon the keys, and in the same number of experiments as in each one of the preceding series, the following results were obtained:

TABLE IV.

Set " V "—Lever pressure—Screened.

Size of series variable by increment of one-tenth from 29.28 mm. to 91.89 mm. Weight 55 g.

Standards.		Average diameter of disc selected.	Difference between average and standard.
Diameter.	Weight.		
60 mm.	35 g.	49.2 mm.	—10.8 mm.
60 "	50 "	53.2 "	— 6.8 "
60 "	65 "	39.1 "	—20.9 "
90 "	55 "	48.4 "	—41.6 "
30 "	55 "	45.4 "	+15.4 "

No regularity can be detected in the results, which indicates that they are purely chance answers. Some thought that the discs were arranged in a series running one way, and about as many thought the series ran in an opposite direction. Others thought they were arranged in an irregular order. Twelve of the observers detected that the standard 35 g. was lighter than any in the series. Few expressed any certainty, a large number doubt concerning their answers to this one. Only one asserted that the entire series was lighter than the standard 65 g., yet a number said they did not feel very sure concerning their selection. That a larger one should be selected to correspond to "l" than for "s" is purely accidental. In many cases I asked the subject to compare "l" and "s," he not seeing them, and invariably they were said to be the same. At the conclusion of all the experiments the two were compared by lifting and in sight. In this case they always declared that "s" was twice as heavy as "l," some said three times as heavy, and could hardly be convinced when the two were placed on the scale-pans of a balance at the conclusion of the experiments, and shown to be equal.

The remarkable point in these results is that, although the entire series consisted of blocks weighing 55 g. each, while three of the standards were 35 g., 50 g. and 65 g. in weight, in a large majority of trials (80%), a disc was found which seemed to correspond. This shows that the threshold of discrimination for this sense is very wide.

Exp. 2, Series II.

Variable size—In sight—Lever pressure.

The screen was then removed and the observer asked to select one equal to each of the standards again. The observers all very soon said that the discs of smallest diameter were heaviest. The average results are given in the following table:

Table V.

Set " V"—In sight—Lever pressure.

Diameter of series variable by increment of one-tenth from 29.2 mm. to 91.89 mm. Weight 55 g.

Standards.		Average diameter of disc selected.	Difference between average and standard.
Diameter.	Weight.		
60 mm.	35 g.	81.4 mm.	+ 2.14 mm.
60 "	50 "	63.9 "	+ 3.9 "
60 "	65 "	46.9 "	—13.1 "
90 "	55 "	74.1 "	—15.9 "
30 "	55 "	37.8 "	+ 7.8 "

In the first three cases where the standards vary by a regular increment in weight, the discs selected vary by a quite regular decrement of diameter. In the last two there appears a great difference between the selections to correspond to "l" and "s." The one has just twice the diameter of the other. This comes from the double factors producing the illusion. In the other series with variable standards and uniform discs to select from, the illusion is not so great.

Exp. 3, Series II.

Set " V"—In sight—Lifted between thumb and finger.

The concluding experiment of the weight tests was made by having the discs lifted between thumb and finger, and alternating the standards with those from which the selections were made. In this test, where greater accuracy in selection is possible, that ought to be observable in the results. Again, if the same law is followed that held in Series I, where there are illusions they ought to be more striking in this table than in Table V.

TABLE VI.

Set " V"—In sight—Active lifting.

Diameter of series. Vary by a regular increment of one-tenth from 29.2 mm. to 91.89 mm. Weight 55 g.

Standards.		Average diameter of disc selected.	Difference between standards and selection.
Diameter.	Weight.		
60 mm.	35 g.	86.1 mm.	+ 2.61 mm.
60 "	50 "	73.8 "	+13.8 "
60 "	65 "	48.8 "	—11.2 "
90 "	55 "	86.7 "	— 3.3 "
30 "	55 "	33.8 "	+ 3.8 "

From this experiment we are led to believe that the illusion comes out most strongly when testing in the manner in which we can ordinarily judge most accurately. In the first three cases the increment of weight is the same as in the previous experiment, but the decrement of diameter is much greater. Although "l" and "s" each weighs 55 g., one of nearly three times as great a diameter is selected for "l" as for "s." In other words, with the standards of the same weight as the series to select from, there are selected those of about the same size as the standards themselves. That is, the same effect as was discovered in Table V is here noticeable, but considerably emphasized.

Résumé.

The main points of the study are these: When we study the effect of selecting from a series of blocks of uniform size, but differing in weight, those that are equal to certain standards, which differ in size (*i. e.*, in density) from the series, we are studying the effect of size upon weight.

On the other hand, when we select out of a series of variable size and variable density, but uniform in weight, the equal of standards that differ in weight, but uniform in size, the question becomes one of the influence of weight upon size.

From the results obtained it appears (1) that the effect of the latter is more marked than the former; (2) the illusions are more striking when the objects are lifted between thumb and finger than when raised by the lever-pressure method; (3) in the lever-pressure method of estimation, the illusion

does not appear in Series I at all, being overbalanced by the constant tendency to underestimate the selected weights; (4) with the lever-pressure method there is a very marked but unaccountable tendency to select a lighter weight as the equivalent of given standards; (5) in the lifting method there is no such exaggerated tendency, and the error is remarkably small; (6) these results agree in general with Dr. Seashore's (except when the lever-pressure method is used, and also with weights of uniform size), but the degree of corroboration cannot well be calculated because of the disparity of methods of experimentation.

PART II.

Study of the Effect of Contour upon Area.[1]

The second part of this study deals with an examination of the possible influence that the contour of a surface may exert upon the judgment of its area. Figures of equal area but of different shapes have consequently different amounts of contour. This study was instituted to determine whether the amount or direction of the contour would prove a factor in influencing the judgment of the area. In other words, does any illusion of area ensue when the contour of a given surface is modified?

Apparatus.

In studying the effect of contour upon judging areas, the following apparatus was used: (a) A set of twenty-one squares, varying in size by a regular increment of 0.025 in area, was made from paper of a dead black color; (b) a set of twenty-one circles made of the same material and of the same areas as the squares, and varying by the same increment. Each of the figures had a white margin (of the card-board on which the black paper was pasted) of 20 mm. on each of two sides and 10 mm. on the other two sides. (For sizes see Table VII.) (c) An instrument was devised whereby a square aperture could be enlarged or contracted, still maintaining the horizontal and perpendicular direction of the sides, and also maintaining perfect right angles. The opening was changed by means of a crank, which wound up a cord attached to the movable sides of the square. A black surface, similar to the paper squares, was revealed each time by the movable sides, which were white. A millimeter scale enabled me to read at a glance the size of the square selected.

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[1] Dr. Dresslar has also made some study of the influence of contour upon estimation of weight. This JOURNAL, VI, 3, p. 360.

Exp. 1, Series III.

Figures in Terms of Squares—Display Board.

The squares were lettered in order of size, and arranged upon a display board, which was simply a board, 3 ft. x 4 ft., covered with black felt cloth. The subject was seated about two meters from the board and asked to select a square from

TABLE VII.

Dimensions of Series of Squares and Circles.

Area of Figure.	Side of Square.	Radius of Circle.
7,818.86 sq. mm.	88.4 mm.	50.0 mm.
7,921.00 "	89.0 "	50.5 "
8,209.66 "	90.6 "	51.1 "
8,372.25 "	91.5 "	51.8 "
8,628.43 "	92.9 "	52.4 "
[1] 8,836.00 "	94.0 "	53.0 "
9,070.35 "	95.25 "	53.7 "
9,312.25 "	96.5 "	54.4 "
9,523.85 "	97.5 "	55.1 "
9,741.75 "	98.75 "	55.8 "
[1] 10,000.00 "	100.00 "	56.4 "
10,225.00 "	101.25 "	57.1 "
10,500.00 "	102.47 "	57.8 "
10,684.00 "	103.75 "	58.5 "
11,025.00 "	105.00 "	59.2 "
[1] 11,289.06 "	106 25 "	59.9 "
11,576.25 "	107.60 "	60.6 "
11,881.00 "	109.00 "	61.3 "
12,155.06 "	110.25 "	62.1 "
12,387.00 "	111.60 "	62.8 "
17,762.81 "	112.98 "	63.5 "

For standards the following figures were used:

TABLE VIII.

Dimensions of Standards.

Area of Standards.	Contour of Triangle.	Contour of Oblong.	Contour of Square.	Contour of Hexagon.	Contour of Circle.
8,836.00 sq. mm.	428.7 mm.	400.0 mm.	376.0 mm.	350.4 mm.	333.0 mm.
10,000.00 "	457.5 "	500.0 "	400.0 "	372.6 "	354.4 "
11,289.06 "	484.8 "	450.6 "	425.0 "	395.4 "	376.4 "

[1] Equal to each of the three standards.

the board, which had an area equal to the standards shown. (For size of these see Table VIII.) The standards were placed, one at a time, in an irregular sequence, in the centre of the display board. As soon as a selection was made the standard was removed and another put in its place. Each one was shown but once. The average of the twenty-five answers is given in Table IX. A great regularity of answers obtains for the standard I. There is more irregularity in the selections for the middle standard, the largest result being given for the triangle, which has the largest amount of contour. But no law can be deduced, since for the other figures there is no regularity of direction. Concerning the average variation nothing very striking is deducible. With all three of the squares there is the least variation, with the first two circles the next to the smallest amount, in the first and third triangle the next, and with the first two hexagons the greatest average variation.

TABLE IX.

Averages of all Results of Comparison of Contour and Area.

STANDARD FIGURES.	Side of Av. *Square* Selected on *Board.*	Average Variation	Side of Av. Square Selected on *Instrument.*	Average Variation	Square root of *Area* of Circle Selected.	Average Variation
Triangle I,	93.5 mm.	3.9 mm.	99.1 mm.	5.6 mm.	96.8 mm.	5.5 mm.
II,	101.4 "	4.7 "	101.8 "	3.8 "	102.2 "	5.17 "
III,	103.9 "	4.3 "	105.4 "	5.23 "	105.8 "	4.6 "
Oblong, I,	94.9 "	3.8 "	99.3 "	6.3 "	94.9 "	4.22 "
II,	98.8 "	5.1 "	102.3 "	4.3 "	100.96 "	5.72 "
III,	101.8 "	5.96 "	105.1 "	4.5 "	104.9 "	4.72 "
Square, I,	93.1 "	1.7 "	100.3 "	6.3 "	96.4 "	4.82 "
II,	99.1 "	2.15 "	104.3 "	4.3 "	101.2 "	3.9 "
III,	105.2 "	2.15 "	109.3 "	4.05 "	106.9 "	4.07 "
Hexagon I,	92.9 "	4.7 "	99.4 "	5.4 "	97.2 "	3.98 "
II,	99.8 "	5.7 "	102.97 "	4.4 "	98.9 "	4.96 "
III,	104.7 "	3.68 "	106.6 "	4.26 "	106.7 "	4.6 "
Circle I,	93.8 "	3.57 "	99.0 "	6.1 "	95.6 "	2.84 "
II,	98.9 "	4.18 "	103.1 "	4.1 "	101.2 "	2.41 "
III,	104.5 "	3.92 "	106.7 "	3.34 "	108.4 "	2.84 "

EXP. 2, SERIES III.

Figures in terms of circles.

With the circles numbered in order according to size and arranged upon a display board similarly to the squares, the

same process of matching circles with the exhibited figures was gone through. The averages are given in Table IX. As in the selection of squares, no law is deducible from the constant direction of the answers with reference to contour. The average variations are a little more suggestive in their distribution. For all of the standard circles there is the smallest average error; the square comes next, the hexagon next, while the greatest variation is about equally divided between the oblong and the triangle. This has a slight indication that the greater the contour the greater the average errors. In this test the average errors are smaller than when selecting squares. However, the average of the selections is not quite so nearly accurate as in case of the squares. The difference is of no consequence. With the selection of circles there is a slight tendency to overestimation. With the squares a slight underestimation is noticeable.

Exp. 3, Series III.

Selection in terms of squares on machine.

In the concluding experiment the standard figures were all placed one at a time, just under the square exposure on the machine. The subjects were asked to direct me whether to enlarge or diminish the aperture so that it should just equal the area of the figure shown. The results show little more regularity concerning the relation of area to contour than is found in the other two experiments. The square is judged the greatest and the triangle the least. The average errors are larger than in the other two tests, and less regularly distributed. Throughout there is a quite decided tendency to exaggeration, which is unexplainable. Had the method of placing the standard under the aperture any appreciable effect, it would be in the opposite direction and would tend to diminish the size of the selected square. It would be on the same principle as the real but unnoticed discrepancy between the upper and lower portions of the Arabic numeral 8 and other similar peculiarities.

In the two previous experiments the standard figure, which was like the series, had considerably the smallest errors. That is, when the series to select from was squares, the squares produced smaller errors in matching, and when the series was circles the smallest errors were on the circles. But by this method no such tendency is to be found. The squares have next to the greatest average errors.

Conclusions.

1. The results show a negative conclusion so far as concerns contour acting as a suggestive factor in producing illusions of area.

2. The results show great accuracy in average estimation and small average variations

3. In using the circular series there is an overestimation, and with the squares an underestimation. That is, the standards appear the same throughout, the circles seem smaller than they really are, and the squares seem larger.

4. The machine method results in a selection of larger squares to equal the standards. That is, the machine square seems smaller than it really is and is enlarged to equal the standard.

5. Throughout, there is a marked exaggeration in selecting the equal of the smallest standards, a slight exaggeration for the largest, and a medium exaggeration for the middle one.

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